Reg. No ..... Name **21P2044**

M. Sc DEGREE END SEMESTER EXAMINATION - JULY 2021

SEMESTER 2 : PHYSICS

COURSE : **16P2PHYT08 : THERMODYNAMICS AND STATISTICAL MECHANICS**

(For Regular - 2020 Admission & Supplementary - 2019/2018/2017/2016 Admissions)

Time : Three Hours Max. Marks: 75

PART A

Answer All (1 mark each)

1. Entropy of the system tends to zero at:
   (a) T= 0 degrees (b) T = infinite (c) T= O K (d) none
2. When 3dice are thrown 125/216 is the probability of getting:
   (a) One six (b) at least one six (c) 2,3,6 combination (d) none
3. For free gas atoms in a cube of volume 'V'. If U is the average energy, PV=
   (a) 2U/3 (b) 3U/2 (c) UT (d) none of the above
4. What is the thermodynamic quantity whose value is related to the magnitude of fluctuations of energy?
   (a) The pressure.
   (b) The heat capacity at constant volume.
   (c) Temperature.
   (d) none of these
5. A plot of pressure vs. temperature for a given substance showing the various phases possible for that particular substance.
   (a) Phase diagram (b) P-T diagram (c) Wein Diagram (d) Histogram

(1 x 5 = 5)

PART B

Answer any 7 (2 marks each)

6. Show that for a single mole of an ideal gas $C_P = C_V + R$.
7. What is a Gibbs Ensemble?
8. Write down the expression for Gibbs free energy.
9. Write down the expression for Helmholtz free energy.
10. Obtain Cv for a diatomic gas
11. Obtain the partition function for a diatomic having rotational motion alone.
12. Write down the partition function of an ordinary hydrogen atom which is a mixture of ortho and para hydrogens.
13. What is Wein's displacement law?
14. What is meant by Fermi Surface?
15. Discuss Fermi distribution function at absolute zero via plot.

(2 x 7 = 14)

PART C

Answer any 4 (5 marks each)

16. Assume that the heat capacity at constant volume of a metal varies as $(aT + bT^3)$ for low temperature. Calculate the variation of the entropy with temperature.
17. A current of 0.5A flows through a 2Ω resistor for 100sec. The system whose initial temperature is 300K is thermally isolated. The heat capacity of the resistor is $0.24JK^{-1}$; for a wide range of temperatures. The temperature of the resistor changes appreciably. What is the entropy change of the system?
18. The average kinetic energy $(=3k_BT/2)$ of hydrogen atoms in a stellar gas is 1eV. What is the ratio of the number of atoms in the second excited state (n=3) to the number in the ground state (n=1)? The energy levels of the hydrogen atoms are $e_n = -a/n^2$ where a=-13.6 eV, and the degeneracy of the nth level is $2n^2$.

19. A system of particles occupying single-particles states and obeying Boltzmann statistics is in thermal contact with a heat bath at temperature T. The populations are 3.1% for 0.0281 eV; 8.5% for 0.0195 eV; 23% for 0.0109 eV; 63% for 0.0023 eV. What is the temperature of the system?
20. Obtain the Fermi wave vector for conduction electrons in lithium having a number density of $4.6 \times 10^{28} m^{-3}$.
21. In sodium there are about 2.6×10^{28} conduction electrons per cubic meter which behave as a free electron gas. From these facts estimate the Fermi energy of the gas and an approximate value of the molar specific heat capacity at 300 K

(5 x 4 = 20)

PART D

Answer any 3 (12 marks each)

22.1. Obtain the expression for Entropy in a canonical system.

OR

2. Obtain the expression for heat capacity of a single 2 level system.

23.1. Obtain the expression for density of states for a single free particle in 3 Dimension.

OR

2. Derive Sackur-Tetrode formula for entropy of an ideal gas.

24.1. Discuss the conditions for chemical equilibrium in terms of Gibbs free energy by taking an example

OR

2. Derive the probability distribution for a grand canonical ensemble.

(12 x 3 = 36)